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(THE TITLE OF THE INVENTION) TURBO-MOLECULAR PUMP

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(INVENTOR)

(ADDRESS) c/o Ebara Corporation
11-1, Haneda Asahi-cho, Ohta-ku, Tokyo

(NAME) Matsutaro MIYAMOTO

(INVENTOR)

(ADDRESS) c/o Ebara Corporation
11-1, Haneda Asahi-cho, Ohta-ku, Tokyo

(NAME) Hiroyuki KAWASAKI

(APPLICANT)

(IDENTIFICATION NUMBER) 000000239

(THE NAME OF APPLICANT) EBARA CORPORATION

(REPRESENTATIVE) Shigeru MAEDA

(PATENT ATTORNEY)

(IDENTIFICATION NUMBER) 100091498

(NAME) Isamu WATANABE

(PATENT ATTORNEY)

(IDENTIFICATION NUMBER) 100092406

(NAME) Shintaro HOTTA

(PATENT ATTORNEY)

(IDENTIFICATION NUMBER) 100102967

(NAME) Susumu Ohata

(OFFICIAL FEE)

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(NAME OF DOCUMENT) SPECIFICATION

(TITLE OF THE INVENTION) TURBO-MOLECULAR PUMP

(CLAIMS)

(CLAIM 1) A turbo-molecular pump in which a vane pumping section and/or a groove pumping section is composed of a rotor and a stator inside a pump casing, characterized in that:

a structure for releasing a circumferential or radial constriction against said pump casing is provided in at least a part of said stator when an abnormal torque is applied to said stator.

(CLAIM 2) A turbo-molecular pump according to claim 1, wherein a fragile section for reducing the abnormal torque is provided in said stator.

(CLAIM 3) A turbo-molecular pump according to claim 1 or 2, wherein a friction reducing structure is provided in at least a part of a space between said stator and said pump casing.

(DETAILED DESCRIPTION OF THE INVENTION)

(0001)

(TECHNICAL FIELD TO WHICH THE INVENTION BELONGS)

The present invention relates to a turbo-molecular pump for evacuating gas by using a high speed rotor.

(0002)

(PRIOR ART)

An example of a conventional turbo-molecular pump is shown in Figure 9. The pump is comprised by a pump casing housing a vane pumping section L_1 and a groove pumping section L_2 which are constituted by a rotor (rotation member) R and a stator (stationary member) S. The pump casing mainly comprises a

cylindrical outer casing 14 and a stator S comprising a base section 15 and fixed section 16. The rotor R is comprised by a main shaft 10 and a rotor cylinder section 12.

(0003)

Between the main shaft 10 and the stator cylinder section 16 are constructed a drive motor 18, an upper radial bearing 20 and a lower radial bearing 22 disposed on the upper and lower sides of the drive motor respectively. Under the main shaft 10, there is an axial bearing 24 having a target disk 24a at the bottom end of the main shaft 10 and an upper and a lower electromagnets 24b on the stator(S) side. In this configuration, a high speed rotation of the rotor R is supported under a five coordinate active control system.

(0004)

Rotor vanes 30 are provided integrally with the upper external surface of the rotor cylinder section 12 to form an impeller, and on the inside of the outer casing 14, stator vanes 32 are provided in such a way to alternately interweave with the rotor vanes 30. These vane members constitute the vane pumping section L_1 which carries out gas evacuation by cooperative action of the high speed rotor vanes 30 and the stator vanes 32.

(0005)

Below the vane pumping section L_1, the groove pumping section L_2 is provided. A spiral groove section 34 having spiral grooves 34a on the outer surface thereof is provided in the rotor cylinder section 12 to surround the stator cylinder 16, and a spiral groove section spacer 36 surrounding the spiral groove section 34 is provided in the stator S. The gas evacuation action

of the groove pumping section L_2 is due to the dragging effect of the spiral grooves 34a in the spiral groove section 34 which rotates at high-speed, against gases.

(0006)

By providing the groove pumping section L_2 at downstream of the vane pumping section L_1, a wide-range turbo-molecular pump can be constructed so as to enable evacuation over a wide range of gas flow rates using one pumping unit. In this example, the spiral grooves of the groove pumping section L_2 are provided on the rotor(R) side of the pump structure, but some pumps have the spiral grooves formed on the stator(S) side of the pump structure.

(0007)

Such turbo-molecular pumps are assembled as follows. Firstly, the groove pumping section spacer 36 is attached by coupling a step 36a of the lower surface of the spacer 36 to a protruded ring section 15a formed on the base section 15. Next, the rotor R is fixed in some position, and the stator vanes 32, which are normally split into two half sections, are clamped around to interweave between the rotor vanes 30. This is followed by placing a ring-shaped stator vane spacer 38, having steps on its top and bottom regions, on top of the clamped rotor vane. This assembling process is repeated for each rotor vane 30 to complete the assembly of the stator vanes 32 around the rotor R.

(0008)

Lastly, the outer pump casing 14 is attached by sliding it around the above-mentioned layered stator vane structure and fixing the flange 14b to the base 15 of the stator S by fasteners

such as bolts, thereby pressing the top stator vane spacer 38 firmly against the stepped surface 14a on the upper inside surface of the outer casing 14 and binding the entire layered assembly and the groove pumping section spacer 36. It can be understood from this assembly structure that the peripheries of each of the stator vanes 32 are pressed together by stator vane spacers 38 located above and below, and similarly the groove pumping section spacer 36 is pressed down by the lowermost stator vane 32, stator vane spacer 38 and the protrusion section 15a of the base section 15, so that the axially applied pressing force prevents induced rotation of the stator vanes 32 and the groove pumping section spacer 36 with the rotor R in the circumferential direction.

(0009)

Also, though not shown in the drawing, sometimes the groove pumping section spacer 36 is fastened to the stator cylinder section 16 of the stator S by bolts to assure the fixation.

(0010)

(PROBLEM TO BE SOLVED BY THE INVENTION)

In such turbo-molecular pumps, operational difficulties are sometimes encountered, such as abnormal rotation caused by eccentricity of rotor R, and they may be accompanied by damaging of the rotor vanes 30. In such a case, the stator structure can also be subjected to significant circumferential or radial force by the rotor R and its debris, which may impact on the stator vane spacers 38 and the groove pumping section spacer 36.

(0011)

These abnormal operating conditions can cause not only

deformation of the stator vanes and spacers 36, 38, but can cause fracture of the pump casing 14 and stator cylinder section 16 in the stator(S) side, or damage to their joints or severing of vacuum connections attached to the pump. Such damage and severing to any parts of the stator cause breakage of vacuum in the whole processing system connected to and evacuated by the pump not only to damage the system facilities and in-process goods, but also to lead to accidental release of gases in the system to outside environment.

(0012)

It is an object of the present invention to provide a turbo-molecular pump of high safety and reliability so that if an abnormal condition should develop on the rotor structure, it will not lead to damage the stator or to cause loss of vacuum in a vacuum processing system.

(0013)

(MEANS FOR SOLVING THE PROBLEMS)

The present invention claimed in claim 1 is a turbo-molecular pump in which a vane pumping section and/or a groove pumping section is composed of a rotor and a stator inside a pump casing, characterized in that: a structure for releasing a circumferential or radial constriction against the pump casing is provided in at least a part of the stator when an abnormal torque is applied to the stator.

(0014)

Accordingly, when an abnormal torque is applied to a stator side of the pump structure due to some abnormal condition developing in the rotor structure, the constriction releasing

structure acts to loosen the stator structure so that the rotation energy of the rotor is absorbed and transmission of torque to the pump casing is prevented and the damage to the pump casing and vacuum connection can be avoided. The constriction releasing structure is normally provided on the stator side of the vane pumping section and/or the groove pumping section, i.e., structures for fixing the vanes 32 or the groove pumping section spacer to the pump casing.

(0015)

The present invention claimed in claim 2 is a turbo-molecular pump according to claim 1, wherein a fragile section for reducing the abnormal torque is provided in the stator. Accordingly, the rotation energy of the rotor is absorbed by fracture of the fragile section of the stator side to be converted into fracture energy, thereby reducing the effects of abnormal torque on the pump casing.

(0016)

The present invention claimed in claim 3 is a turbo-molecular pump according to claim 1 or 2, wherein a friction reducing structure is provided in at least a part of a space between the stator and the pump casing.

(0017)

(EMBODIMENTS OF THE INVENTION)

In the following, preferred embodiments will be presented with reference to the drawings. Figures 1 and 2 relate to the first embodiment of the turbo-molecular pump in the present invention. The present pump shares some common structural features with the conventional pump shown in Figure 9, such as

vane pumping section L_1 comprised by alternating rotor vanes 30 and the stator vanes 32, the groove pumping section L_2 having spiral groove section 34 and groove pumping section spacer 36. As well, the outer pump casing is used to press down the stator vanes 32, stator vane spacers 38 and the groove pumping section spacer 36. Therefore, an overall illustration of this embodiment is omitted.

(0018)

In the present pump is constructed so that, when abnormal torque is applied to the stator vane 32 due to abnormal conditions developing in any rotor(R) components, a part of the stator vane spacers 38 is able to move radially outward. This is achieved by having the uppermost vane spacer 38a and the lowermost vane spacer 38b each of which is comprised by two vane spacer halves 40. The inner surface of the casing 14 has grooves 42, 44 extending all around its circumference at corresponding heights with that of the outer surfaces of the uppermost and lowermost vane spacers 38a, 38b. The width of the grooves 42, 44 is slightly larger than the thickness of the stator vane spacers 38a, 38b.

(0019)

During the normal operation of such a pump, no large torque will be applied to either the stator vanes 32 or the stator vane spacers 38 in the circumferential or radial direction, and the assembly, consisting of stator vanes 32 and stator vane spacers 38, retain their positions because of mutual friction therebetween. The uppermost and lowermost stator vane spacers 38a, 38b retain their ring shape, and hold individual stator vanes 32 in contact with the associated stator vane spacers 38.

(0020)

If an abnormal condition should develop in the rotation of the rotor R or if the rotor R should break for whatever reason, and either or both of the stator vane spacers 38a, 38b are subjected to a large force acting in circumferential or radial direction, stator vane spacers 38a, 38b are pushed outwards, and the upper and lower split spacers 40 are separated into half pieces and the half pieces enter into the grooves 42, 44. In this condition, other stator vane spacers 38 become loose and rotatable because of the release of constrict in an axial direction against the stator S. This causes the stator vanes 32 and the stator vane spacers 38 to be dragged with the rotor R, and causes the rotation energy of the rotor R to be gradually dissipated, and the rotor R eventually stops. Because an axial constrict of the stator vanes 32 and stator vane spacers 38 against the outer casing 14, 15 is released and the torque of the rotor R is not transmitted to the stator(S) side, the damage to the outer casing 14, 15 or to connection to external facility is not produced.

(0021)

In the embodiment presented above, the uppermost and the lowermost stator vane spacers 38a, 38b are made into split rings, but either one of the split type spacer is enough for the purpose of invention, and also, any one or more of the spacers 38 disposed in the mid-section of the rotor R can be selected as the split type spacer. It is also possible to split the spacers into three or more than three pieces.

(0022)

Figures 3 and 4 show a second embodiment of the turbo-molecular pump according to the invention. This pump is also constructed so that the axial constrict of the stator vane 32 is released at an early stage of the onset of abnormal condition. As shown in Figure 4, support pins 46 are provided equally spaced in the circumferential direction in a space between the vanes 32c of the uppermost stator vane and lowermost stator vane 32a, 32b. The support pins 46 are fitted between the step surface 14a and the uppermost stator vane spacer 38c as a "support rod" and a plurality of pins are provided equally spaced in the circumferential direction. The length of the pins is chosen to be slightly greater than the thickness of the uppermost stator vane or lowermost stator vane 32. Therefore, clearances S are formed between each stator vane 32 and the step surface 14a of the outer casing 14 or the bottom surface of the lowermost stator vane spacer 38d.

(0023)

These support pins 46 is made in such a way that, during normal operation of the pump, they are sufficient in their strength and number to support the stator vane spacer 38 in place, and if some abnormal condition should develop, such as twist or torque occurred between the stator S and the rotor R, then the pins can be readily broken. Also, the sizes of the clearances S are chosen to be in a range of about 50~100 μm such that, during normal operation, the rotor vanes 32 do not experience any slack.

(0024)

Such a pump operates as follows. During normal operation, the pump will remain in the condition illustrated in Figure 3,

but if the rotor R should break or experience abnormal rotation to cause some twist or torque to be developed between the stator S and the rotor R, the support pins 46, will either fall down or break. This causes the upper and lower clearances to be spread into the build-up structure positioned therebetween. The assembly becomes loose and releases the axial constricting force exerted on the stator vases 32 and the stator vane spacers 38. The result is that the stator vane spacers 38 become rotatable with respect to the stator S, and the torque being transmitted to the stator S is reduced to prevent the damage to the pump.

(0025)

Figures 5 to 7 show a third embodiment of the turbo-molecular pump according to the invention. In this pump as shown in Figures 6 and 7, all the stator vane spacers 50, excepting the uppermost stator vane spacer in the vane pumping section L_1, are provided with a series of threaded holes 50a and bolt holes 50b alternately distributed in a circumferential direction so that a bolt 52 as a fastening member can be inserted through a bolt hole 50b of an upper stator vane spacer 50 to be fastened into a threaded holes 50a of a lower stator vane spacer 50 so as to assemble all the stator vane spacers 50 to each other. The lowermost stator vane spacer 50 is fixed to the top of the groove pumping section spacer 54.

(0026)

The strength of these bolts 52 is selected such that, when abnormal torque is transmitted to the spacer 50 due to breaking of the rotor R or abnormal rotation, the bolts will fracture. The strength of bolts 52 is determined either by selecting the

material or diameter, or by providing a fracture-induction site such as a notch on a certain position of the bolts.

(0027)

Groove pumping section spacer 54 in the groove pumping section L_2 is fixed to the base section 15 of the stator S by inserting a bolt 56 through a bolt receiving slit 55 and screwing the bolt 56 into the base section 15. The strength of the bolt 56 is selected so that the bolt will break when torque of a certain magnitude is transmitted to the spacer 54.

(0028)

In this embodiment, the inside corners of the protrusion 17a which supports the bottom end of the groove pumping section spacer 54 are chamfered, and the height H of the contact surface 17b contacting the bottom end of the groove pumping section spacer 54 is made shorter than that of the case shown in Figure 10. Also, in this embodiment, a friction reducing device is provided in the form of low-friction structures 58 such as a cylindrical low friction member which is made of a low friction material, ball bearings and rollers.

(0029)

Such a pump operates as follows. When abnormal torque acts on each stator vane spacer 50 or groove pumping section spacer 54, the bolts 52, 54 fastening the stator vane spacers 50 and groove pumping section spacer 54 to the stator S are fractured, thus releasing the axial compression makes the stationary members rotate with respect to the stator S. This causes the energy of the rotor R to be dissipated, and lowers the torque transmitted from the rotor R to the stator S, thus

preventing damage to the stator S.

(0030)

Also, because the friction reducing devices 58 is provided in the space between the casing 14 and the stator vane spacers 50/groove pumping section spacer 54, frictional force resulting between the casing 14 and stator vane spacers 50/groove pumping section spacer 54 is reduced after the bolts 52, 56 are broken. Also, because the contact area between the case section and the groove pumping section spacer 54 is made small, the force transmitted to the stator S is further reduced. It is possible to use a low friction structure such as ball bearings and rollers instead of low-friction member 58. The purpose of providing a circumferential groove 42 so as to surround the outer edge of the uppermost stator vane spacer 38 has been explained in the first embodiment.

(0031)

Figure 8 shows a fourth embodiment of the pump according to the present invention. The outer casing 14 in this case is made of an intake-side casing 14A and an exhaust-side casing 14B, which are attached to form a complete casing 14. Stator vane spacers 50 in the vane pumping section L_1 are axially fixed layer by layer by using the bolts 52 as in the previous embodiment.

(0032)

The exhaust side casing 14B has a step surface 60 at the top end which engages the step surface, and the groove pumping section spacer 54 has a flange section 54a, so that the groove pumping section spacer 54 is attached to the exhaust-side casing 14B by fastening the step surface 60 to the flange section 54a

by bolts 56. The strength of the bolts 56 is selected so that they will break at a given torque. In this embodiment also, friction reducing structures 58a, 58b such as cylinder-shaped low-friction member, ball bearings and rollers are provided in the spaces between the stator vane spacers 30 and the intake-side casing 14A on the one hand, and the groove pumping section spacer 54 and the exhaust-side casing 14B. The turbo-molecular pump of this embodiment provides the same protective effects described above.

(0033)

It should be noted that, in the above-mentioned embodiments, the applications of various structures of the present invention were represented by those pumps having a vane pumping section L_1 and groove pumping section L_2. However, the structure of the present invention can be applied to those pumps having only the vane pumping section L_1 or only the groove pumping section L_2. For those wide-range pumps having both pumping sections L_1 and L_2, it is understandable that the structure of the present invention can be provided only on one of the two pumping sections.

(0034)

(EFFECTS OF THE INVENTION)

As described above, according to the present invention, when an abnormal torque is applied to a stator side of the pump structure due to some abnormal condition developing in the rotor structure, the constriction releasing structure acts to loosen the stator structure so that the rotation energy of the rotor is absorbed and transmission of torque to the pump casing is

prevented and the damage to the pump casing and the vacuum connection to the external facility can be avoided. Therefore, it is an object of the present invention to provide a turbo-molecular pump which has high safety and reliability so that if an abnormal condition should develop on the rotor structure, it will not lead to damage to the stator or pump casing and will not cause loss of vacuum in a vacuum processing system.

(BRIEF DESCRIPTION OF THE DRAWINGS)

(Fig. 1)

Figure 1 is a cross sectional view of a turbo-molecular pump in a first embodiment.

(Fig. 2)

Figure 2 is a plan view of a stator vane spacer used in the uppermost stage and the lowermost stage of the vane pumping section shown in Figure 1.

(Fig. 3)

Figure 3 is a cross sectional view of a turbo-molecular pump in a second embodiment.

(Fig. 4)

Figure 4 is a cross sectional view through a plane A-A in Figure 3.

(Fig. 5)

Figure 5 is a cross sectional view of a turbo-molecular pump in a third embodiment.

(Fig. 6)

Figure 6 is a plan view of a rotor vane spacer shown in Figure 5.

(Fig. 7)

Figure 7 is a cross sectional view through a plane B-B in Figure 6.

(Fig. 8)

Figure 8 is a cross sectional view of a turbo-molecular pump in a fourth embodiment.

(Fig. 9)

Figure 9 is a cross sectional view of a conventional turbo-molecular pump.

(DESCRIPTION OF THE REFERENCE NUMERALS AND SIGNS)

10 main shaft

12 rotor cylinder section

14 outer pump casing

15 base section

16 stator cylinder section

18 drive motor

30 rotor vane

32 stator vane

34 spiral groove section

38, 38a, 38b, 38c, 50 stator vane spacer

42, 44 groove

46, 48 support pin

52, 56 shear bolt (fastening member)

54 spiral groove section spacer

58, 58a, 58b friction reducing structure

R rotor

S stator

L_1 vane pumping section

L_2 groove pumping section

(Designation of Document) ABSTRACT

(Abstract)

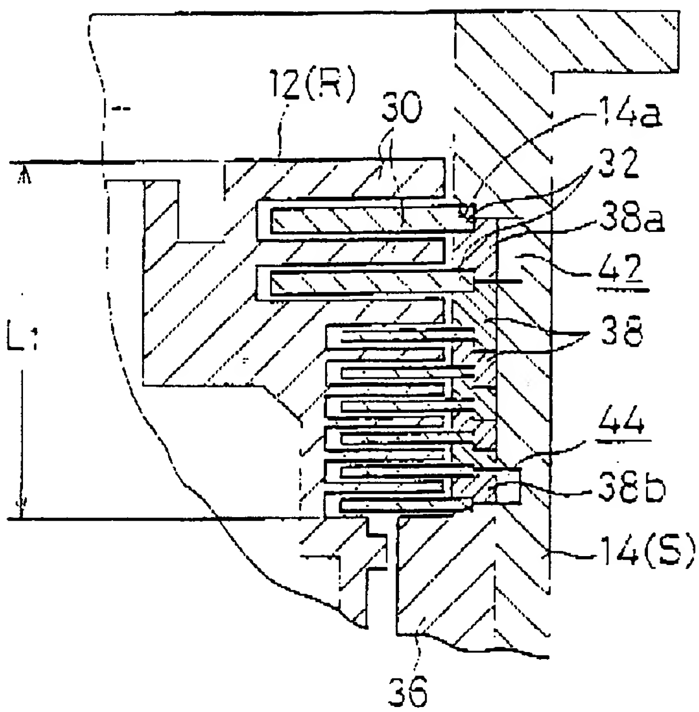
(Problem) The present invention is to provide a turbo-molecular pump of high safety and reliability which will not damage the stator and will not cause loss of vacuum in a vacuum processing system when an abnormal condition develops on the rotor structure.

(Means for Resolution) A turbo-molecular pump in which a vane pumping section L_1 and/or a groove pumping section L_2 is composed of a rotor R and a stator S inside a pump casing 14, characterized in that: a structure for releasing a circumferential or radial constriction against the pump casing 38a, 42 is provided in at least a part of the stator S when an abnormal torque is applied to the stator S.

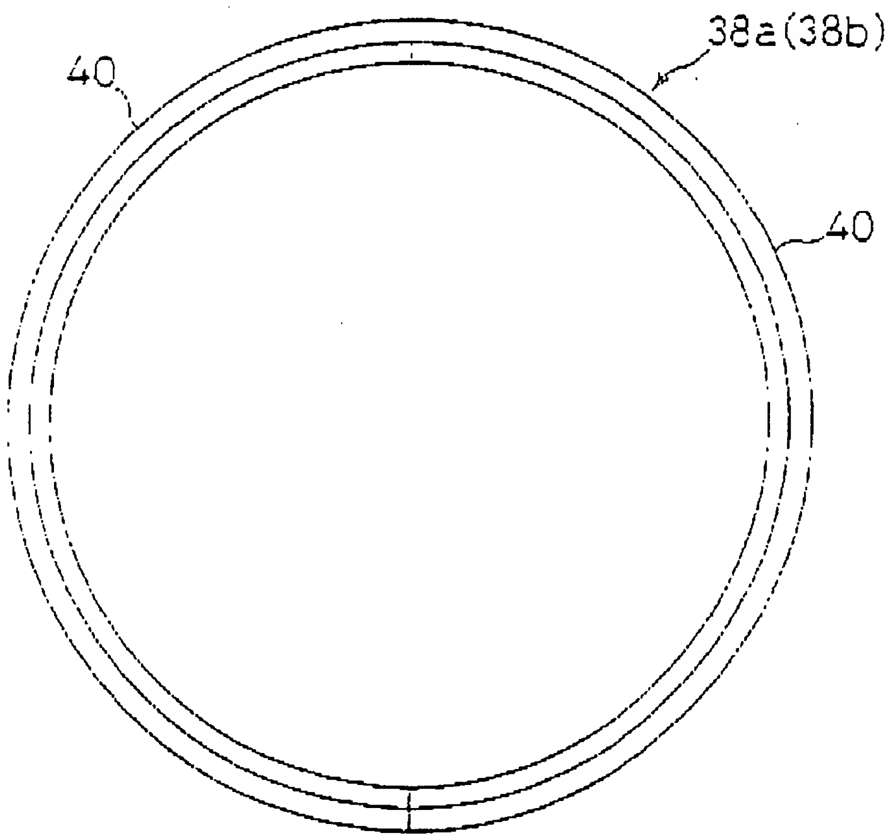
(Selected Figure) Fig. 5

REFERENCE NUMBER EB1259P
(NAME OF DOCUMENT) DRAWINGS

(FIG. 1)



(FIG. 2)



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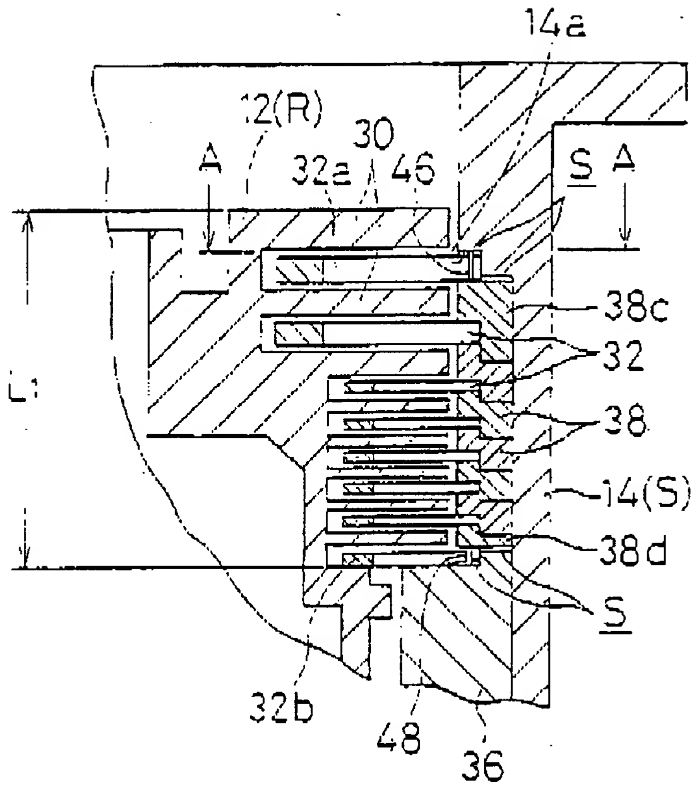
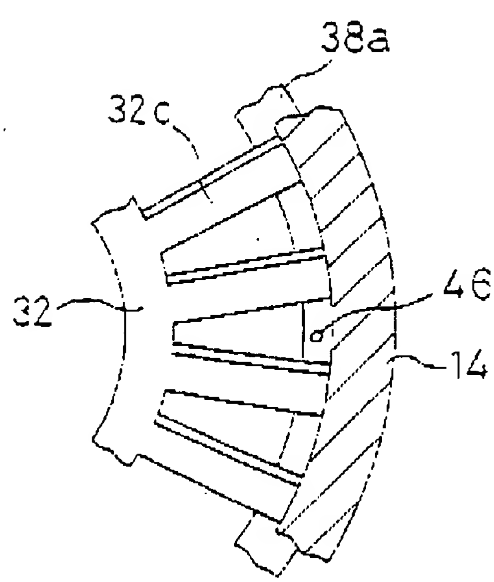
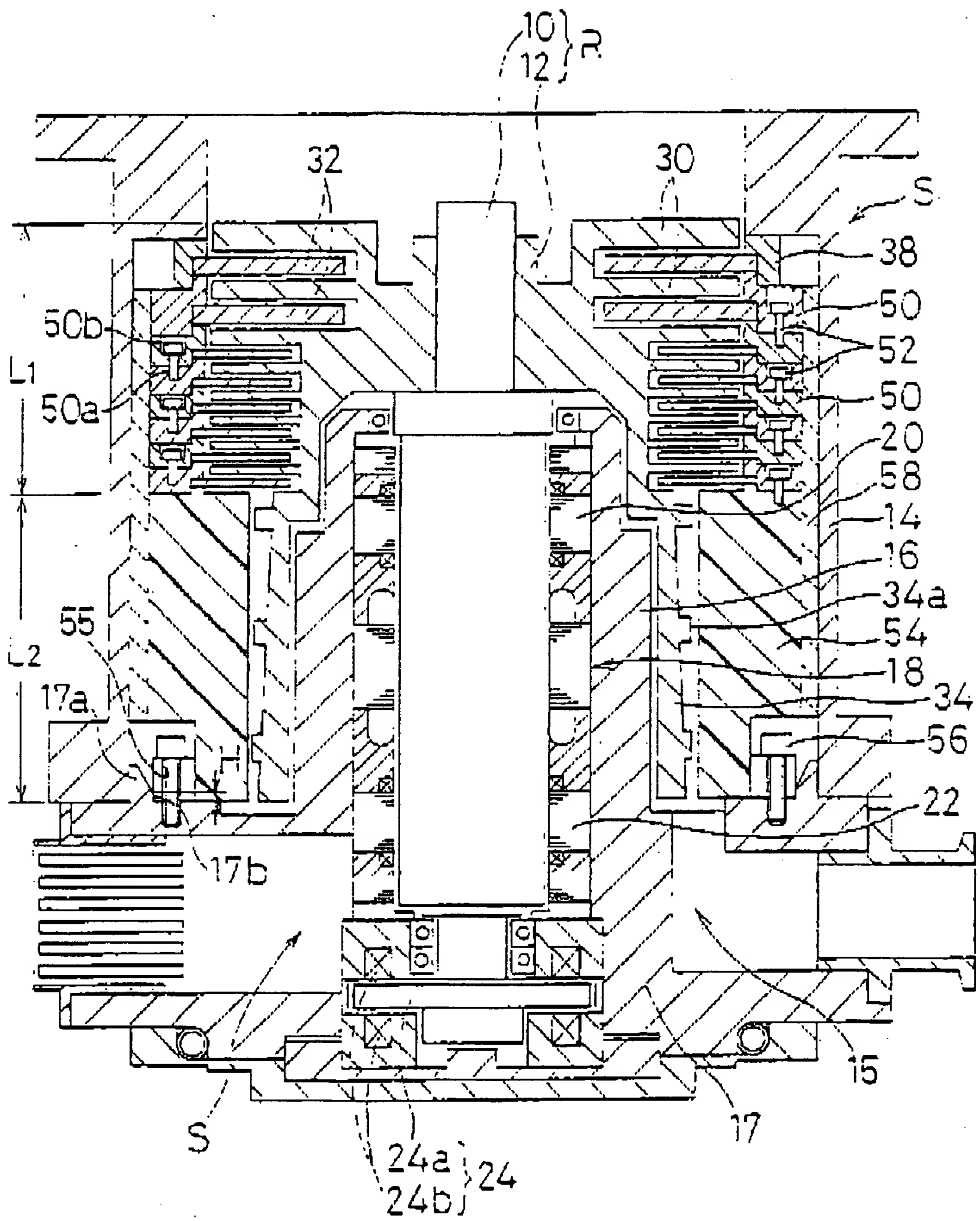
(FIG. 3)



(FIG. 4)



(FIG. 5)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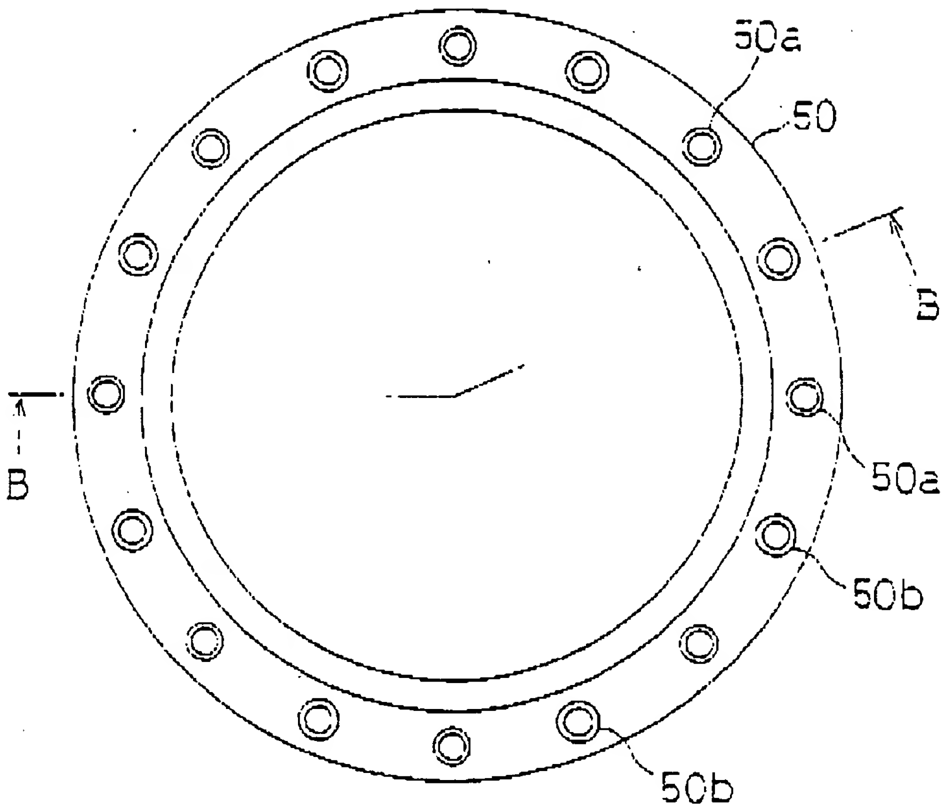
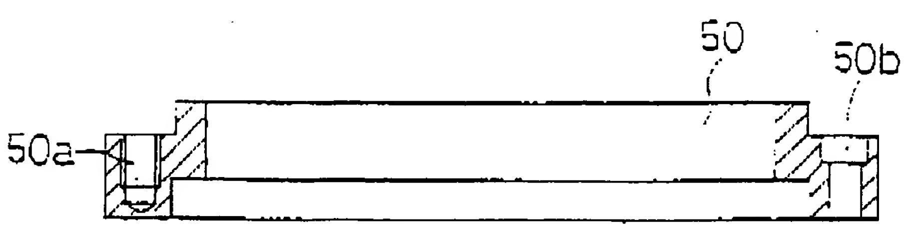
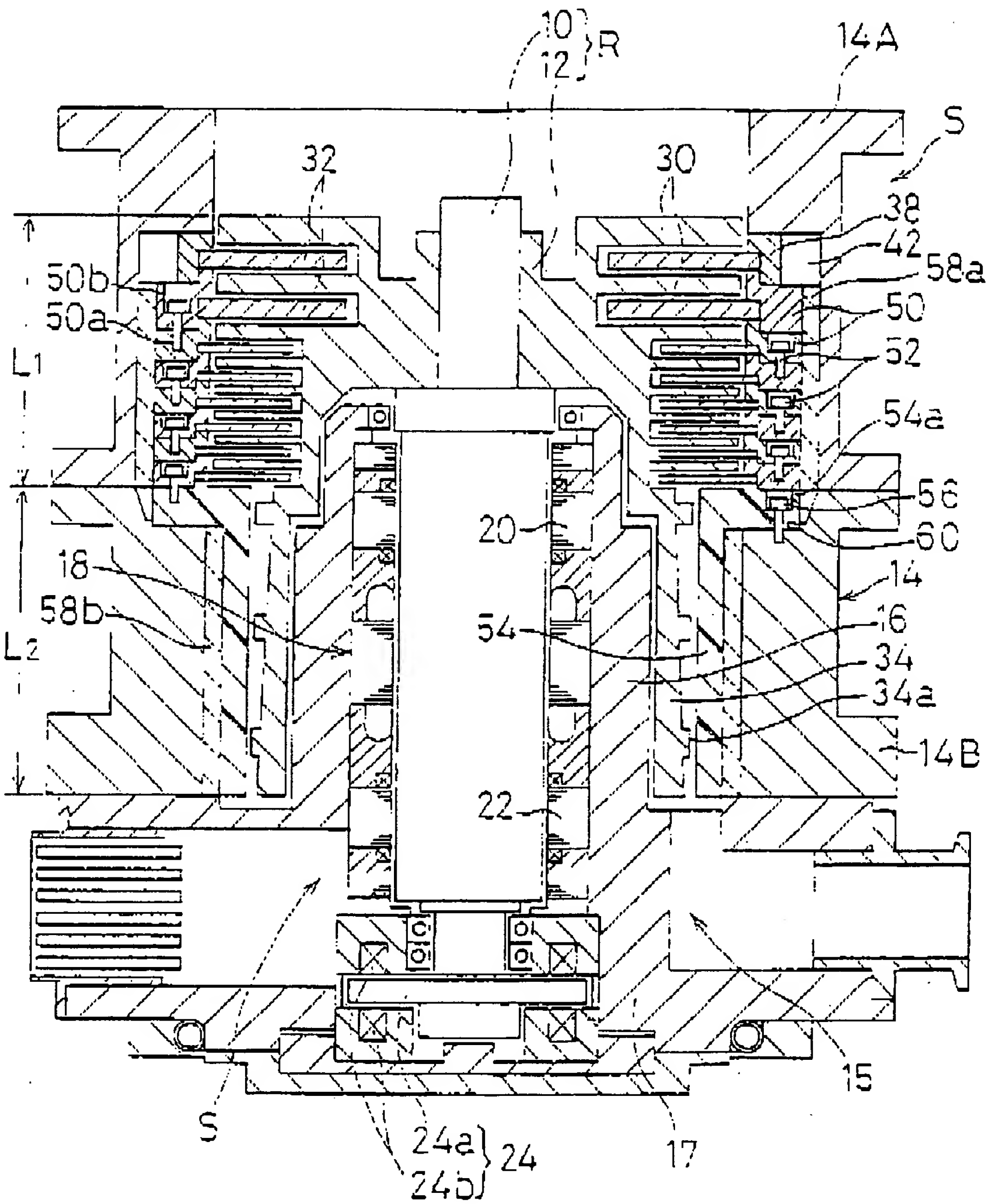
(FIG. 6)



(FIG. 7)



(FIG. 8)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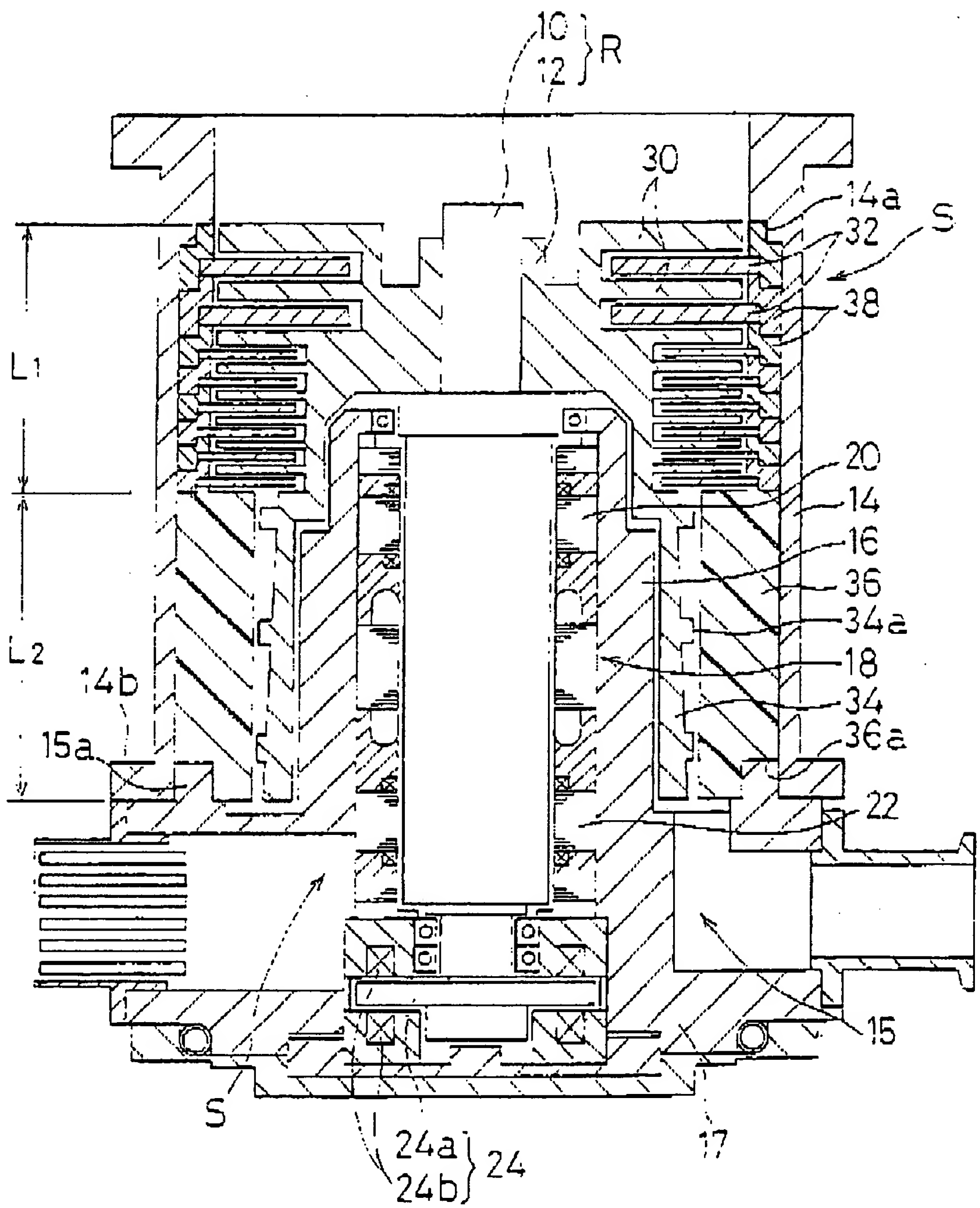
(FIG. 9)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